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Willingness to pay for ecosystem services provided by irrigated agriculture in Northeast Thailand

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ABSTRACT

In addition to producing food products, irrigated agroecosystems provide important services that contribute to societal well-being but are often not taken into account by policy-makers. This paper investigates how the public in Northeast Thailand values these services. A choice experiment approach was developed to elicit the implicit prices of these services. We also investigate heterogeneity of respondents using a latent class (LC) approach. The results indicated that individuals are willing to pay for irrigated agricultural services that provide drought mitigation, preserves water quality and environment, and rural landscapes (RL). However, we observed important willingness-to-pay (WTP) heterogeneity related to gender, age, and income. Our results suggest that a society's demand for the nonmarket services of irrigated agriculture especially drought mitigation, water quality, and RL is significant, even in a middle-income country in Southeast Asia. Therefore, agricultural policies should balance or trade-off between these different services. In short, results from this research could be applied as a useful informative component for the future development of irrigated agricultural policy.

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model

1. Introduction

In Asia, rice is the main crop cultivated in irrigated agroecosystems. In addition to producing food products, these systems, as inundated, interconnected paddy fields, provide important functions and services such as flood and flow control, and groundwater recharge (Groenfeldt 2006). Besides, when good agricultural practices are followed, they produce ecosystem services (ES) close to those of natural wetlands such as providing a bird habitat and water filtration (Natuhara 2013). Finally, through irrigation, rice farmers maintain traditional landscapes (MRC 2010).

All of these services contribute to the well-being of Asian societies but most are public goods that are not traded on markets. As a result, these contributions are seldom considered in the policy-making processes, and agriculture may not provide the set of services demanded by the societies (FAO 2007; Kenter et al. 2011). For example, underestimating the benefits of biodiversity within cultivated areas led to a sharp reduction in the number of species and varieties present in agroecosystems. In turn, the reduction in biodiversity reduced the provision of a variety of supporting services to surrounding ecosystems (Tschamntke et al. 2012). In the same way, not taking into account the negative effects of pesticides on nontarget organisms is one of the causes for an overuse of pesticides in Thailand irrigated rice fields. This resulted in accumulation of harmful pesticides

in the environment (Poolpak et al. 2008), and negative impact on nontarget species. Nitrogen and phosphorus fertilizers are also heavily applied in agroecosystems for improving yields but their overuse also had some consequences for human health and the environment. Impacts of nutrient loss from agroecosystems include groundwater pollution and increased nitrate levels in drinking water, eutrophication, increased frequency and severity of algal blooms, hypoxia and fish kills, and 'dead zones' in coastal marine ecosystems (Power 2010). Finally, farming and farming styles play a crucial role in maintaining or degrading the distinctive landscape and wildlife quality of such areas. In addition, targeted support for the maintenance of landscapes can influence how farmers manage these landscapes (Schmitzberger et al. 2005; Wrba et al. 2008).

However, quantifying a society's demand for these functions is not easy in the absence of markets (Ferrari & Rambonilaza 2008). Choice experiments (CEs) have been increasingly used to elicit social preferences and implicit prices of public goods and services. Agriculture ES have also been valued using CEs (e.g. Kallas et al. 2007). More recent examples include van de Schoot et al. (2015) who applied CE to determine the preferences of Bulgarian citizens regarding the provision of healthcare service attributes and Mejía and Brandt (2015) who evaluated the potential impacts of various pricing strategies for managing nature-based tourism in

Ecuador's Galapagos National Park. In this context, the main objective of our paper is to investigate how a society values the different ES provided by agroecosystems. Thailand was selected as an interesting case study because it is a major irrigated rice producer and the production-oriented support awarded to rice farmers has been heavily debated recently. At the time of the study, the government was guaranteeing price of paddy delivered to the government at around 150% of the world market price. This price subsidy came without requirements about the cultivation practices and the provision of some of the nonmarket ES. Besides, irrigation water is provided free of charge to farmers, and they are not required to maintain water quality. Many observers complained about the negative impact of irrigated rice agriculture on ecosystems (pollution by fertilizers and pesticides, overuse of fertilizers, loss of biodiversity). Like Thailand, many countries of Southeast Asia have developed some support mechanisms for the irrigated rice agriculture, showing that our results are potentially interesting for other countries of the region.

This article contributes to the literature in two main ways. First, research on the demand for agricultural nonmarket functions was exclusively conducted in developed countries characterized by very small agricultural sectors in terms of both population and gross national product (GNP) shares (Campbell 2007; Kallas et al. 2007; Vera-Toscano et al. 2007; Zander et al. 2007). In that respect, the case of Thailand is interesting because it is a middle-income country and the share of the rural population and of the contribution of agriculture to GNP has sharply declined in recent decades. As the relative importance of agriculture decreases, we wish to assess whether citizens have a demand to maintain some of the nonmarket functions that are likely to be affected by changes occurring in rural areas, and in the management of agroecosystems. Second, most studies looking in this literature did not look at the possible heterogeneity of preferences within the population. We used a latent class (LC) model to investigate the preference heterogeneity among the respondents, and the influence of socioeconomic characteristics on those preferences and the resulting willingness-to-pay (WTP) for the different services. To our knowledge, our study is the first to assess the WTP for the nonmarket functions of irrigated agriculture in Southeast Asia in particular and in middle-income countries more generally.

2. Case study

2.1. Study area

The northeast region of Thailand is the most populous and poorest region of Thailand. It comprises approximately one-third of the country's

population. Nakhon Ratchasima Province (hereafter, NR), with a population 2.59 million in 2010, is the second-largest province in the country. NR was chosen because it includes within a reasonable distance, some rural districts where both irrigated and nonirrigated rice agriculture are found, and some urbanized districts of the large regional capital. The provincial capital is one of the fastest-growing cities in Thailand in terms of infrastructure, social, and economic development. The activities and resources of the province are diversified. The gross provincial product of agricultural sector is 14.9%, while nonagricultural sector occupies 85.1% (industry 19.8%, commerce 22.5%, and others – finance, real estate, health care, education, governmental services, transportation, etc. – 42.8%). Annual gross domestic product (GDP) per capita in 2010 was approximately 66,000 Baht (USD 2100) compared with the 159,000 Baht (USD 5000) country average. Agricultural land covers a large proportion (66%) of NR's area, half of which is cultivated with rice. Only 7.4% of the agricultural land in the province is currently irrigated. Government budget constraints and strict environmental regulations for water resources development project are partly explaining the current low investment in irrigation projects in the province. However, the potential for increasing the irrigated area is deemed important (RID 2010).

2.2. Identification of attributes associated with irrigated agriculture

Identifying the attributes that would have an impact on respondent's choices was an essential stage of the study. We conducted in-depth interviews with nine experts from academic and government institutions with recognized experience in the fields of irrigation and water resources, land and agriculture, and environment. During the interviews, the experts were asked to identify the important nonmarket services provided by irrigated agricultural project and their related attributes. Then, we held three focus groups with different compositions to produce and refine a list of interpretable attributes and levels that could subsequently be used in the CE survey. The first group consisted of eight officials from national and regional institutions responsible for agriculture, environment, irrigation, and water resources. The second group consisted of 12 NR farmers who have their cultivation lands both in and out irrigated area and differed with respect to age and gender. The third group consisted of 10 nonfarmer NR residents and included government officials, business owners, and employees. Each meeting was conducted in the Thai language, lasted approximately 2 hours and was moderated by the first author.

During this phase, participants associated irrigated agriculture to four families of services, namely food production (and associated economic activities), drought mitigation, water-related ES, and rural landscapes (RL). We also constructed contrasted policy scenarios with participants that would help irrigated rice agriculture provision more of these services. First, the irrigated agricultural project could increase supply of water to agriculture for those having or not already access to water. This would result into yield increase (private good) and boosted economic activity in the region (public good). In fact, supporting agricultural productivity was seen by many interviewed stakeholders as contributing to economic activity of the province. Second, the project could also work on the drought mitigation functions. The province is prone to frequent droughts that affect both rural and urban areas. A better organization of water delivery to both areas during drought events could prevent households drought related expenses (e.g. purchase of water trucks during dry spells, cost of digging well and pumping). Third, the project could also work on the quality of water in the irrigated areas. This water is not only used for production but is also used for recreational purposes such as fishing and swimming. Besides, less polluted water decreases the potential damages to the fauna found in these water systems (fields and canals). Although irrigated rice agriculture is often associated to increase use of chemical inputs and pollution, the project could, for example, promote low-input technologies in irrigated rice areas (training, incentives, supporting and providing organic substances, etc.). Finally, the project could help in maintaining RL in a region where rice is also a cultural heritage. Currently, the absence of irrigation leads some farmers to fallow or abandon their lands and/or leave the

area for other income-generating activities. The last attribute, payment, was also discussed with experts and stakeholders. A local tax that would be paid annually per household (HH) basis in order to collect additional resources would be devoted to the improvement of ES provided by irrigated rice agriculture. Since, it was seen as the more practical channel to collect project funds, and to make all respondents aware that they would really have to pay in case the project started. This tax would be decided by the local authorities.

Project scenario included contrasted goals for these different functions. It was emphasized that all goals aimed at improving the respondents' own utility. The summary of attributes and attributes levels are presented in Table 1.

2.3. Experimental design

We first conducted two pilot studies on samples of 52 and 52 randomly selected NR respondents. Respondents' answers to the first two pilot studies suggested that the range of values for the payment attribute was too narrow to capture the demand for the services. A third pilot study conducted on 53 additional randomly chosen respondents with an increased range for the payment attribute was finally deemed satisfactory since it induced sufficiently diverse response.

We analyzed the responses of this last survey using a multinomial logit (MNL) model to obtain the coefficients expected values. Using these expected values as priors, we developed an efficient design with 12 choice tasks and blocked it into 2 orthogonal blocks of 6 choice tasks each using Ngene v.1.1.2 (Rose & Bliemer 2009). Blocking was used to simplify the choice task and avoid respondent fatigue. For the

Table 1. Attributes and attribute levels used in the choice experiment.

Attribute	Variable		Attribute level		
	Short name	Type	1	2	3
Paddy yield	Yield	Numeric	Average yield 2250 kg/ha/year (SQ)	Increase yield to 3750 kg/ha/year	Increase yield to 7500 kg/ha/year
Drought mitigation	Drought	Numeric	No drought mitigation may be affected by drought every year (SQ) (99%)	Mitigate drought may be affected by drought every 2 years (50%)	Mitigate drought may be affected by drought every 3 years (33%)
Water quality and Environment	Environment	Nominal dummy variables	Low level of water quality be able to use for industrial purposes	Medium level of water quality be able to use for agricultural purposes (SQ)	High level of water quality, aquatic animals conservation and safe swimming purposes
Rural landscapes	RL	Nominal dummy variables	Rural landscapes are deteriorating, some agricultural lands are abandoned/being changed (SQ)	Maintain rural landscapes	
Annual payment for local tax (USD/household/year)	Pay	Numeric	26	52	104

SQ refers to the status quo situation

design, environment and RL attributes were treated as dummy variables. The most widely used measure of efficiency of a design are the D-error (that minimizes the determinant of the asymptotic variance-covariance matrix when assuming some prior values), and the S-estimate (a lower bound on the sample size to obtain significant parameter estimates (Bliemer & Rose 2009)). Ngene outputs indicated that the D-error of the design was 0.15, and the S-estimate was 5.2 suggesting that given the priors assumed, the design would need to be replicated at least 5.2 times for all parameters to be statistically significant with a *t*-ratio of at least 1.96 (Rose & Bliemer 2009). However, one choice set was dismissed because it was behaviorally unrealistic, as was done in other studies (e.g. Zander et al. 2013).

The final design included two blocks: one with six choice sets and one with five. We evaluated the consequences of this unbalanced block structure on the

design efficiency criteria using the evaluation mode of Ngene. The new D-error was 0.19 and S-estimate of 7.01 not only indicating an efficiency loss but also suggesting that the large sample taken for the final survey, in this case about 150 surveys per block would largely offset this loss.

Each respondent was provided one of the blocks, and we randomized the order of the choice sets presented to each respondent. Each choice set included three unlabeled alternatives, including the status quo. Each alternative was described using the five attributes specified. Since the project was presented as a locally funded (local taxes), the payment value for the status quo (SQ) was made equal to zero, as respondents are not currently paying any local taxes related to the additional services proposed.

An example of a choice card is provided in Figure 1.




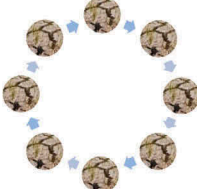
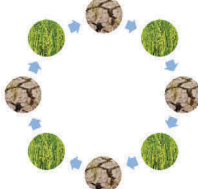
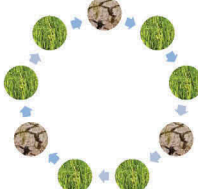






Functions and Services from irrigated agriculture	Status quo	Alternative 1	Alternative 2
1. Supplement water/crop grown in dry-season/getting more yield	 <p>Avg. yield 360 kg/rai/yr</p>	 <p>Increasing yield 1,200 kg/rai/yr</p>	 <p>Increasing yield 1,200 kg/rai/yr</p>
2. Drought mitigation	<p>Be affected by drought Almost every year (99%)</p> 	<p>Be affected by drought One of two years (50%)</p> 	<p>Be affected by drought One of three years (33%)</p> 
3. Control & monitor water quality in irrigation canal and natural stream	<p>Moderate quality: able to use for agricultural purposes</p> 	<p>High quality: able to use for aquatic animals conservation and safe swimming purposes</p> 	<p>Moderate quality: able to use for agricultural purposes</p> 
4. Agricultural lands support to maintain rural landscapes	<p>Abandoned land, No agricultural activities</p> 	<p>Agricultural land conservation maintains rural landscapes</p> 	<p>Abandoned land, No agricultural activities</p> 
Willingness to contribute (Baht/Household/Year)	0	3200	1600
I choose			

Figure 1. Example choice set.

2.4. Survey methods

We conducted face-to-face interviews in NR with individuals selected from the population of four NR districts, which differed in their levels of urbanization and development. Of the 350 interviews requested, a total of 305 respondents accepted to be interviewed and answered all questions. The respondents were selected by stratified random sampling based on residence (urban vs. rural), gender, age, and occupation. This proportional stratification reduced the potential sampling error and increased the likelihood of generating a representative sample of the population.

The personal interviews were conducted at respondents' homes. Questions were addressed directly to the household heads (identified as the person responsible for providing for the most daily expenditures) or to the next household member 20 years of age or older living on the premises.

The interviews were organized to ensure that the respondents received adequate and equal information and to minimize possible difference of interpretation between the respondents. This was critical to avoid information bias and potential hypothetical biases. Respondents were also encouraged to ask for additional information or clarification. The interviewers did not note any misunderstanding or fatigue among respondents during the interviews.

The interviews were conducted in three stages. First, the concepts and purposes of the survey were thoroughly explained to the potential respondents. The enumerator presented the overview of the different functions provided by irrigated agriculture using pictorial cards (A4 size) and brief descriptions. The terminology or other research definitions were clearly discussed with respondents. The enumerator also explained that the attributes and attribute levels of the irrigated agriculture scenarios were selected as a result of prior research including in-depth interviews with experts and focus group discussions. Each attribute and attribute level was defined to ensure uniformity in understanding. The discussion continued until the respondents were able to properly conceptualize the various attributes.

Second, self-report questions were asked prior to the choice questions to determine the respondents' perceptions of the current attribute levels of irrigated agriculture. Then, the researchers presented the choice sets for the respondents' selection. The enumerators were consistently available to address the respondents' doubts and questions. Before the selection, we also reminded the respondents that they would eventually have to pay for their selections from their household budgets. When the respondents were comfortable with the context, the enumerators asked them to choose an alternative based on their preferences. Subsequently,

follow-up questions were asked to determine respondents' motivations especially, when respondents chose the SQ option in order to be able to identify the protestors.

Third, the respondents' socioeconomic and demographic characteristics (i.e. place of residence, gender, age, number of household members, household monthly income, formal educational attainment, occupation, and agricultural working experience) and responses to general opinion questions were recorded. This information was necessary to assess the representativeness of the sample in NR and, crucially, to use these data as explanatory variables to investigate heterogeneity in preferences.

2.5. Modeling framework

In a typical discrete choice experiment (DCE), individuals are asked to select one among several alternatives, associated with nonmarket goods and services, that differ by observable attributes while considering their budget constraints (Louviere et al. 2000). Most models developed to analyze those hypothetical choices are built upon the MNL model within a random utility model (RUM), whereby consumers are assumed to maximize their utility when choosing among different alternatives with contrasted attributes (McFadden 1974).

The MNL model assumes that the utility of an individual i provided by an alternative j is:

$$V_{i,j} = \beta' \cdot X_{i,j} + \varepsilon_{i,j}, \quad (1)$$

where $X_{i,j}$ is a vector of attributes for alternative j proposed to i , β is a vector of weights that maps attribute levels onto utility, which are assumed to be homogenous across consumers, and $\varepsilon_{i,j}$ is the stochastic component of the indirect utility function. As this utility function is not observable, the MNL model estimates the coefficients that would most likely generate the observed choices. If the error terms follow an Extreme Value I distribution, it can be shown that the probability that the individual i chooses the alternative j is (Louviere et al. 2000):

$$\Pr(y_{i,j} = 1) = \frac{\exp(\beta' \cdot X_{i,j})}{\sum_{j=1}^J \exp(\beta' \cdot X_{i,j})}, \quad (2)$$

where $y_{i,j}$ is an indicator variable taking the value 1 if the respondent i chose the alternative j and 0 otherwise. This probability is used to construct the log-likelihood function (Greene & Hensher 2003) to be maximized to estimate β .

The β can be interpreted as the vector of marginal utilities for the different attributes. Thus, the marginal rate of substitution of money for an attribute k , that is, the respondent's WTP for greater quantities of that attribute, can be estimated as:

$$WTP_k = -\frac{\beta_k}{\beta_p}, \quad (3)$$

where β_k represents the marginal utility for attribute k , and β_p represents the marginal utility for money.

The basic MNL model serves as a reference point but is limited to several assumptions. First, it assumes the independence of irrelevant alternatives (IIA), in which choice situations are uncorrelated. This hypothesis may be considered overly restrictive to represent decision-making (Kahneman & Knetsch 1992). Second, as the model only allows for one parameter for the entire population, tastes for observed attributes are assumed to be homogeneous. This assumption is also very restrictive as one can expect a diversity of preferences in the population.

To address those limitations, researchers have developed several alternative models. Among them, two are of particular interest for our study. The first, referred as random parameter logit (RPL) or mixed logit model, considers that the β parameters are distributed in the population according to continuous random distributions to be chosen by the analyst. This solves the IIA issue of MNL model, gives some interesting information about the diversity of preferences within the sample, and also usually results in better fit of the data (Train 2003). However, RPL results are dependent on the researcher's decision about the functional form of the parameters' distribution. Most applications assume normal or lognormal distributions, but usually do not check the consequences of alternative distributions on their results. A second approach, often referred as multinomial logistic LC approach, considers that heterogeneity of preferences can be analyzed by grouping respondents into a discrete number of homogenous classes of preferences, each having its own parameters. As a result, LC does not require any assumption about the distribution of the parameters (Greene & Hensher 2003). However, the analyst has to decide on the 'right' number of classes to be found in the sample. There are no established criteria to define this number, but analysts usually compare model results in terms of Bayesian information indicator (BIC) ($-2LL + \log N \times \text{npar}$, where LL is log-likelihood of the model, npar is the number of parameters to be estimated, and N is the number of cases), McFadden pseudo R^2 , and plausibility of the results.

We used the LC approach for this study since it required fewer assumptions. The LC models use quasi-panel data whereby one individual is proposed T consecutive scenarios. The probability for an individual i belonging to a specific class $c \in \{1, \dots, C\}$, of choosing one alternative $j \in \{1, \dots, J\}$ proposed in choice situation t is:

$$\Pr(y_{i,j,t} = 1 | i \in c) = \frac{\exp(\beta'_c X_{i,j,t})}{\sum_{j=1}^J \exp(\beta'_c X_{i,j,t})}, \quad (4)$$

where β_c is a vector of utility parameters specific of class c . As the analyst ignores which respondent is in which class, the model estimates the probability that individuals belong to a certain group. The prior probability π_c that a respondent i belongs to class c is also expressed in a MNL equation:

$$\pi_{i \in c} = \pi_c = \frac{\exp(\theta'_c Z_i)}{\sum_{c=1}^C \exp(\theta'_c Z_i)};$$

$$c = 1, \dots, C; \theta_1 = 0,$$

where Z_i is a vector of observable characteristics of individuals related to class membership. These two probabilities are used to construct the log-likelihood function to be maximized to estimate β (Greene & Hensher 2003). Once the model is estimated, with the use of the Bayes' formula, we can obtain the posterior probabilities of the different classes to determine the relative importance of each class.

3. Results

3.1. Sampling characteristics and case validation

A total of 305 respondents accepted to be interviewed and answered all questions. A balance between rural (54%) and urban (46%) residents was nearly achieved. The mean age in the sample was 39, and the sample was nearly balanced with respect to gender. The four main careers, namely, farmer, business owner, government officer, and employee (both salary and temporary), covered 93% of the sample, whereas the rest were retired persons, housewives, and others. A plurality of the respondents (46%) had a monthly household income in the range between 10,000 and 30,000 Thai Baht (THB), which corresponds to the range of the province (21,000–26,000 THB). Average household size in the sample (4.37) was in line with the size of the province (4.3). About two-thirds of the respondents had agricultural working experience (described as own farming job, previous experience as farmer, or being a member of farming family). This demonstrates that the sample is representative of Thai society, in which many urban dwellers have family ties with farming households. The characteristics of sample and NR Province are presented in Table 2.

Respondents were considered protesters when they chose to keep the status quo option for all choices and justified their choice by one of the following statements: (a) 'Government should take all responsibility for this investment', (b) 'Policies are unlikely to happen', (c) 'Direct beneficiaries

Table 2. Sample characteristics and provincial statistics.

	Characteristics	Sample (%)	NR Province (%)
Place of residence	Rural	53.77	75.38
	Urban	46.23	24.62
Gender	Male	45.90	49.45
	Female	54.10	50.55
Age	20–35	37.70	
	36–50	46.89	
	>50	15.41	
Agricultural working experience	Yes	70.82	
	No	29.18	
Household member	1–4	60.98	Avg. 4.3
	5–8	37.05	
	>8	1.97	
Household income (THB/month) ^(a)	<10,000	17.05	21,000–26,000
	10,001–30,000	45.57	
	30,001–50,000	16.72	
	>50,000	20.66	
Occupation	Employee	24.26	
	Farmer	19.67	
	Business owner	29.51	
	Government officer	19.67	
	Others	6.89	

^(a) 1 USD equals approximately 31 THB

should pay’, (d) ‘I do not want to pay for any proposed plan’. Those respondents choosing SQ but not mentioning one of those four reasons were kept in the analysis. About 65 respondents (21%) were identified as protesters, thus leaving an effective sample of 240 respondents for subsequent analysis.

3.2. Model specification and selection

The LC model was designed to evaluate the class utility function:

$$U(a) = \beta_0 \cdot ASC + \beta_1 \cdot P_a + \beta_2 \cdot Y_a + \beta_3 \cdot D_a + \beta_4 \cdot E1_a + \beta_5 \cdot E2_a + \beta_6 \cdot L_a, \quad (6)$$

where P_a , Y_a , D_a , $E1_a$, $E2_a$, and L_a are the values taken by each alternative scenario a for the attributes payment (continuous), yield (continuous), drought (continuous), environment (effect coded for medium and high level of water quality – the base being a low level of water quality), and RL (effect coded) respectively. Since the respondents were asked to choose among a SQ and two unlabeled alternatives, the utility function did not include a constant per alternative. However, we included an effect-coded alternative-specific constants (ASC) variable, that is, coded minus one (–1) for the two unlabeled alternatives and one (1) for the SQ. This allowed us to capture an eventual preference for the SQ situation that could not be captured with the current set of attributes. Given this coding, a significant positive β_0 would increase the utility of the SQ option and decrease the utility of new alternatives independently of their attributes; this would indicate a preference for the SQ or a ‘status quo bias’ that may happen because respondents find the task of selecting the preferred option too complex, they are uncertainty about the

trade-off that they would be willing to make, or they do not trust the government to actually implement any of the projects (Adamowicz et al. 1998; Colombo et al. 2006). Besides, the use of effect coding ensured that the term β_0 was not confounded with the utility of the omitted environmental attribute level (Bech & Gyrð 2005). In terms of interpretation, the estimate for the marginal utility for the low level of environment will be $-(\beta_4 + \beta_5)$, while the marginal utility for the medium and high levels will be, respectively, β_4 and β_5 .

Twelve model variations were tested and compared using the BIC, and Pseudo R^2 indicators (Table 3). Models 1–4 are LC models with a number of classes varying from two to five, where the probability model for class selection did not include socioeconomic variables. Models 5–8 are the same LC models but where the probability model for class selection did include some socioeconomic variables, that is, gender, age, and income (other available socioeconomic variables were not significant and were removed from the model). Results from these eight models suggested that a LC with three or four classes and the presence of socioeconomic variables that influences the probability of belonging to a class would be the most suitable.

For each LC model, we tested whether coefficients for each attribute were significantly different across classes using Wald tests. The tests consistently suggested that the coefficients were significantly different across classes for yield, environment, and RL, but not significantly different for the attributes pay, drought, and ASC. Therefore, we ran the models 9–12, where the classes’ coefficients varied across class only for the yield, effect coded environment, and RL attributes. The corrected McFadden Pseudo R^2 was higher for models with five classes. However, both BIC and

Table 3. Evaluation of the tested models.

Model No.	No of classes	Socioeconomic Variables ^(a)	Equality constraints ^(b)	LL	BIC(LL)	Pseudo R^2 ^(c)	Corrected pseudo R^2 ^(d)
1	2			-983.80	2049.81	0.193	0.180
2	3			-943.89	2013.83	0.226	0.207
3	4			-921.98	2013.85	0.243	0.218
4	5			-910.37	2034.48	0.253	0.221
5	2	x		-979.11	2067.84	0.197	0.180
6	3	x		-935.10	2051.07	0.233	0.206
7	4	x		-900.26	2052.62	0.261	0.224
8	5	x		-880.20	2083.75	0.278	0.229
9	2	x	x	-988.18	2069.53	0.189	0.175
10	3	x	x	-945.05	2038.08	0.225	0.202
11	4	x	x	-903.68	2010.14	0.259	0.228
12	5	x	x	-891.21	2040.01	0.269	0.230

(a) Socioeconomic variables added: gender, age, and income (effect coded)

(b) Coefficients for payment, yield and drought identical across the different classes

(c) Pseudo $R^2 = \text{McFadden Pseudo } R^2 = 1 - (\text{LL}/\text{LL0})$ (d) Corrected pseudo $R^2 = 1 - (\text{LL} - K)/\text{LL0}$ (K = no. of parameters)

plausibility of results suggested that a model with four classes including socioeconomic variables and equality constraints for the pay, drought, and ASC coefficients would be the best model. The following results and discussions will be based on the results of this model.

3.3. Parameter estimates

The likelihood parameter estimates and the posterior probability of the selected model are presented in Table 4.

The coefficients associated with the payment and drought attributes, treated as identical across classes, were significant and of expected signs; increasing the payment or the increasing the occurrence of droughts that could not be mitigated decreased utility. The coefficient ASC associated with the SQ, equal across classes, was significantly negative. The negative sign was not expected and suggests a 'negative' bias

toward the SQ, that is, a positive perception of changes. This is in contrast to other studies that have found positive bias toward SQ (Kenter et al. 2011; Greiner 2015). One possible explanation for this negative bias for SQ is that, with the help of additional questions to clarify why respondents chose SQ, we have been able to screen out more protesters than other study.

The coefficients associated with the yield, environment, and RL were allowed to vary across classes, and we found important contrasts in their values indicating high heterogeneity in the population toward those attributes. The parameters of the Class 1 (54.7% of the sample) were all highly significant and of the expected signs: increase in yields, environmental quality, and maintaining RL all improved utility. The parameters of the Class 2 (25.6% of the sample) were significant for the Environment-M. The parameters of the Class 3 (17.1% of the sample) were significant and of expected signs for the yield and

Table 4. Parameter estimates.

Attribute ^(a)	Class 1 (s.e.)	Class 2 (s.e.)	Class 3 (s.e.)	Class 4 (s.e.)	Wald (=)
Pay	-0.038*** (0.004)	-0.038*** (0.004)	-0.038*** (0.004)	-0.038*** (0.004)	–
Yield	0.489*** (0.107)	0.078 (0.068)	5.945** (2.418)	-4.347*** (1.403)	3.40E-06
Drought	0.046*** (0.005)	0.046*** (0.005)	0.046*** (0.005)	0.046*** (0.005)	–
Environment-M	0.416*** (0.104)	0.599*** (0.139)	-0.322* (0.191)	2.825 (1.827)	8.80E-28
Environment-H	1.471*** (0.120)	0.126 (0.154)	0.193 (0.166)	-3.284 (2.726)	
Rural landscapes	1.463*** (0.119)	0.098 (0.133)	0.759*** (0.145)	-2.128 (1.659)	4.80E-34
ASC	-0.621*** (0.114)	-0.621*** (0.114)	-0.621*** (0.114)	-0.621*** (0.114)	–
Posterior	0.547 (0.038)	0.256 (0.034)	0.171 (0.034)	0.026 (0.010)	

Log-likelihood: -903.68; BIC: 2010.14; AIC-3: 1918.3

Likelihood-ratio chi-squared statistic: 86,907.9 (df = 203), Prob = 0.000

McFadden Pseudo R^2 : 0.259

Significance code: 0.001 '***' 0.01 '**' 0.05 '*'

(a) Environment-M = maintaining water quality at medium level (water quality for agricultural purposes); Environment-H = Enhancing water quality at high level (water quality for aquatic animals conservation and safe swimming purposes)

RL. The coefficient associated with Environment-M was significantly negative indicating members of this class do not want to pay for the environmental attribute. The parameters of the Class 4 (2.6% of the sample) were also significant for the yield attribute. However, the coefficient for yield was negative indicating an aversion for this attribute.

3.4. Classes characterization by socioeconomic variables and WTPs

We analyze the model in relation with socioeconomic attributes of the respondents and the probability of belonging to one of the four classes. The parameters of this model are presented in Table 5. A large positive coefficient for a parameter indicates that respondents with this characteristic have a higher than average probability of belonging to that class. The Wald test did not allow us to reject the null hypothesis (coefficient jointly different from zero) for the socioeconomic variables age, gender, and income (effect coded), but allowed to reject it for the variable area (urban vs. rural dwellers) and education level.

As only a few variables were significant, we also tested the potential effects of the education level and the living area on the distribution of LC classes using Fisher exact tests (Table 6).

Finally, the WTPs for the different attributes and their standard deviations calculated using the delta method is presented in Table 7.

These three sets of information allowed us to characterize better the four classes identified by the model.

The Class 1 had a higher proportion of younger respondents, with higher education and higher income, and living in rural area. This class was willing to pay for all the proposed attributes, especially for the environmental and RL attributes. However, WTP for increasing yield was low when compared with the market price (180–250 USD/T).

The Class 2 had a higher proportion of person living in rural areas, female, with relatively lower than average education and income. Age was not correlated with this class. This class was mainly willing to pay for the mitigation of drought. The WTP for drought mitigation was 1.2 USD/HH/year to be able to increase drought mitigation ability by 1%. This would correspond a contribution of 60 USD/HH/year to reduce by 50% the vulnerability to drought. The WTP for yield was significant and close to the world market price. This second class did not consider as important the environmental and RL aspects, but giving some priorities to the food production aspect of agriculture. However, this should be taken with caution as the marginal utility for yield was not significant from zero.

The Class 3 had a higher proportion of respondents living in urban districts and attaining high level of education. The class contained a higher proportion of medium income. Respondents of this class were mainly willing to pay for the drought, environmental, and RL attributes. Their WTP for increased yield was not found significant. They recognized the value of clean water. However, they had probably lower expectations in terms of water quality, and their WTP is consistent to Class 1.

The WTP for the RL is following the same patterns than for the environmental attribute. Only Classes 1 and 3 showed significant positive WTP for maintaining RL and the WTP was higher for Class 1 respondents. WTP for this attribute was not found significant for the other two classes.

Finally, the Class 4, though only 2.6%, contained a higher proportion of people living in urban districts. Respondents of this class were mainly characterized by their highly negative WTP for yield; they also had no significant WTP for the other attributes except drought mitigation.

Finally, we estimated the compensating surplus (CS) for changes relative to the present situation (Table 8). We constructed two possible scenarios and we calculated the CS welfare measure for the average respondent. The utility being linear in all attributes, the CS can be calculated by summing the relevant marginal WTPs. The first scenario concentrates on the yield (1.5 ton/Ha/year more than the SQ situation) and drought services (20% increase in drought mitigation capacity as compared with SQ) and do not maintain water quality and RL. The second scenario did not improve yields but concentrated on the drought (20% increase in drought mitigated), environment (high level), and maintenance of RL. The mean WTP was 60.2 USD/HH/year in the first scenario and 38.3 USD/HH/year in the second scenario. However, it is important to note that scenario 2 is likely to be preferred by a larger share of the population, represents 72% of the sample

Table 5. Estimated parameters of the class probability.

Variable ^(a)	Class 1 (s.e.)	Class 2 (s.e.)	Class 3 (s.e.)	Class 4 (s.e.)	Wald (0)
Intercept	2.798*** (0.688)	1.127 (0.835)	−0.820 (0.987)	−3.105 (1.648)	0
Gender-F	−0.150 (0.170)	0.512*** (0.191)	0.058 (0.215)	0.605 (0.406)	0.057
Age	−0.034** (0.015)	−0.013 (0.018)	0.031 (0.021)	0.016 (0.033)	0.046
Income-1	−0.795* (0.428)	0.523 (0.440)	−0.178 (0.452)	0.449 (1.014)	0.039
Income-2	−0.010 (0.345)	−0.001 (0.388)	−0.850** (0.411)	0.862 (0.908)	
Income-3	0.586 (0.843)	1.013 (0.865)	0.344 (0.876)	−1.943 (2.458)	
Income-4	0.218 (0.416)	−1.535** (0.632)	0.684 (0.445)	0.632 (1.027)	

Significance code: 0.001 '***' 0.01 '**' 0.05 '*'

^(a)Gender-F = Female; Income-1 = Income <10,000; Income-2 = 10,001–30,000; Income-3 = 30,001–50,000; Income-4 = Income >50,000

Table 6. Cross table of classes with education level and living area.

Attribute	Class 1	Class 2	Class 3	Class 4	Sample average	P-value (Fisher test)
Education level						
1: Primary	0.12	0.26	0.26	0.33	0.18	0.03
2: Junior-high	0.06	0.14	0.07	0.17	0.09	
3: Above Junior-high	0.82	0.60	0.67	0.50	0.73	
Area						
1: Rural	0.53	0.72	0.33	0.33	0.54	0.005
2: Urban	0.47	0.28	0.67	0.67	0.46	

Numbers represent the class (column) percentages of the cross table.

Table 7. WTPs for different attributes and classes.

Attribute ^(a)	Class 1 (s.e.)	Class 2 (s.e.)	Class 3 (s.e.)	Class 4 (s.e.)
Yield	13.035*** (2.419)	158.447* (65.774)	2.075 (1.752)	-115.840** (39.155)
Drought	1.215*** (0.127)	1.215*** (0.127)	1.215*** (0.127)	1.215*** (0.127)
Environment-M	11.101*** (3.012)	-8.571 (5.259)	15.970*** (3.482)	75.297 (49.244)
Environment-H	39.194*** (3.417)	5.152 (4.290)	3.351 (4.014)	-87.524 (73.446)
Rural landscapes	38.986*** (2.695)	2.606 (3.372)	20.236*** (3.518)	-56.715 (44.961)
ASC	-16.564*** (7.06)	-16.564*** (7.06)	-16.564*** (7.06)	-16.564*** (7.06)

Significance code: 0.001 **** 0.01 *** 0.05 **

(a) Environment-M = maintaining water quality at medium level (water quality for agricultural purposes); Environment-H = maintaining water quality at high level (water quality for aquatic animals conservation and safe swimming purposes)

Table 8. Consumer surpluses under two contrasted scenarios.

	Class1	Class2	Class3	Class4	Mean
Percentage	54.7	25.6	17.1	2.6	
Surplus scenario 1:	10.9	228.3	-8.7	-182.5	60.2
Yield and drought					
Surplus scenario 2:	70.5	-8.7	11.5	-8.7	38.3
Drought, environment and landscapes					

(Classes 1 and 3) than scenario 1. Class 2 would prefer the scenario 1 as it would largely gain under this scenario, but only represents 26% of the sampled population.

We did not compare these consumer surpluses with current agricultural subsidy schemes with two reasons; first, current transfers to agriculture are usually done through agricultural price subsidies, whether the crops are irrigated or not, so it is difficult to evaluate budgets allocated to irrigated crops only. Second, the anticipated services are supposed to be used by local populations, especially water systems and drought mitigation services, and payments would be made locally. However, while comparison is difficult, the results are showing that environmental and amenity aspects can generate a surplus for a large share of the population.

4. Discussion

The results suggest that in addition to the option of increasing the rice yield, respondents are concerned with and willing to pay for the nonmarket services of irrigated agriculture, including the mitigation of drought-related problems, maintenance and enhancement of water quality and environment, and maintenance of RL. This is consistent with the results obtained in other countries (e.g. Campbell (2007) and Kallas et al. (2007) also applied the CE for their study).

We found that the WTP for drought mitigation was uniform in the surveyed population. This is likely because the study was conducted in Northeast Thailand, which is subject to more frequent drought events than the other parts of the country. However, WTP could be considered low as this corresponds to less than 1% of the average yearly household income in that province.

The study also found a significant heterogeneity in the population for some of the services evaluated. In particular, the WTPs for yield were much contrasted between Class 1 and Class 2. The first class presented rather low implicit price of yield. A plausible explanation is that we asked respondents to concentrate on the non-private benefits, that is, the benefits that are

not only about farmers' revenues (private) but also about regional development it would bring. A second explanation is that the Thai Government is already supporting this function by providing irrigation free of charge to farmers. Therefore, the respondents may believe that additional support was not warranted for this particular service. Other studies have reported similar trends. For example, Zander et al. (2013) also found that respondents in Australia did not exhibit any significant WTP for increasing income from irrigated agriculture but were more inclined to pay for waterholes for aboriginal people and recreational fishing quality.

Significant and positive WTP for environmental attribute were only found in Classes 1 and 3, representing about 72% of our sample, this denotes that water quality is widely recognized and valued across the population. One possible reason may be that Thai Government has made awareness campaigns on environmental issues in recent years. It is interesting to see that Classes 1 and 3 both have a higher proportion of high-education-level people.

Only Class 1, with a higher proportion of younger respondents had a significant WTP for the high level of water quality. These results contrast with those of Kenter et al. (2011) who found that young groups expressed a stronger preference for lower-cost scenarios and concluded that the value placed on the environmental services increased with age.

More than two-third of samples had positive WTP for maintaining RL. This may reflect a fundamental aspect of Thai society, in which agriculture, especially rice agriculture, serves not only as source of food but is also considered an important cultural heritage to preserve. Kallas et al. (2007), using a hybrid conditional logit model, found a globally higher WTP for agricultural services among urban populations in their study in Spain. They also reported that support for maintaining populations in rural areas was stronger among rural populations. Boulanger et al. (2004) in another European context also noted that individuals living far from urban areas were more concerned with the environmental condition of rural areas. However, our study did not allow concluding about any relation between WTP for RL services and residence area of the respondents.

Our results can also be compared with the findings of Vivithkeeyoonvong et al. (submitted), who used an analytical hierarchy process (AHP) and clustering techniques to rank the different services by irrigated agriculture in the same province. We did not find the same clear differences between an 'Agricultural business-oriented' class that would be concerned mainly by the economic aspects of irrigated agriculture (increasing rice yield to develop the region's agro-business activities), and

'Environmentally aware' and 'Socially aware groups' of their study. Instead, we found a group that are considering all the nonmarket functions (Class 1), and a group that did not consider environmental aspects, except drought mitigation (Class 2). The differences in the grouping of respondents obtained from this CE and their study using AHP, a non-monetary technique, can be explained by the difference in terms of approaches (e.g. ranking attributes without having to pay for it in the case of AHP), and also by a slightly different mix of services that were presented to the respondents in that study.

5. Conclusions

This paper verified that a segment of the population in Northeast Thailand are recognizing and would be willing to pay at least for some of ES provided by irrigated agriculture. This provides a rationale for public (governmental) support. Currently, support takes the form of the free provision of irrigation water. However, we identified societal demand for some specific services from irrigated agriculture, especially regarding water quality and RL. As such, support for irrigated agriculture would be more efficient if it were channeled to those farmers willing to provide these services (e.g. those who would respect water quality by using less pesticide, and those who wish to maintain RL).

On another note, most of the services such as water quality would be provided locally. Consequently, this would require the decentralization of their management at meaningful eco-regional levels to respond to the local demands. This leads to one potential weakness of this study, since we did not consider the current Government expenditures for irrigated agriculture at a national scale. In particular, our hypothetical scenarios proposed some additional local taxes to enhance services provided locally. Further research would be needed to compare this study with a study where the scenario proposed would be paid by reallocating the government budget instead of adding new local taxes (Morrison & MacDonald 2011; Remoundou et al. 2014).

We should also emphasize that our results are quite specific of the northeastern type of climate. Some attributes might be considered as preference in some parts of the country and not elsewhere. Other valuable services associated with irrigated rice agriculture such as flood control, recharge of the underlying aquifer, and biodiversity in wetland rice fields may be considered as more important services in other areas. Thus, additional research should be conducted in other regions of the country. We also noted that we are likely to

underestimate the total welfare benefit derived from irrigated agriculture; however, this is counter-balanced by the potential presence of hypothetical bias, which is known to lead to overstatements of true WTP in stated preference methods (Murphy et al. 2005).

Finally, our analysis should be refined to test our hypothesis about the way respondents did analyze the presented scenarios. In particular, many papers have suggested that some respondents may have different ways to use the information given to them to make their decisions. One important family of processing strategy, known as attribute nonattendance (ANA), is investigating whether some respondents may not consider all their attributes when taking their decisions. However, there are still a lot of debates among researchers whether the high levels of ANA found in earlier papers are due to the modeling approach or to the true presence of ANA in the sample. Using latest techniques to detect ANA, such as methodologies proposed by Hess et al. (2013) or Lagarde (2013) would bring additional perspectives about the WTP for the ES linked to irrigated rice agriculture in Southeast Asia.

Disclosure statement

No potential conflict of interest was reported by the authors.

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